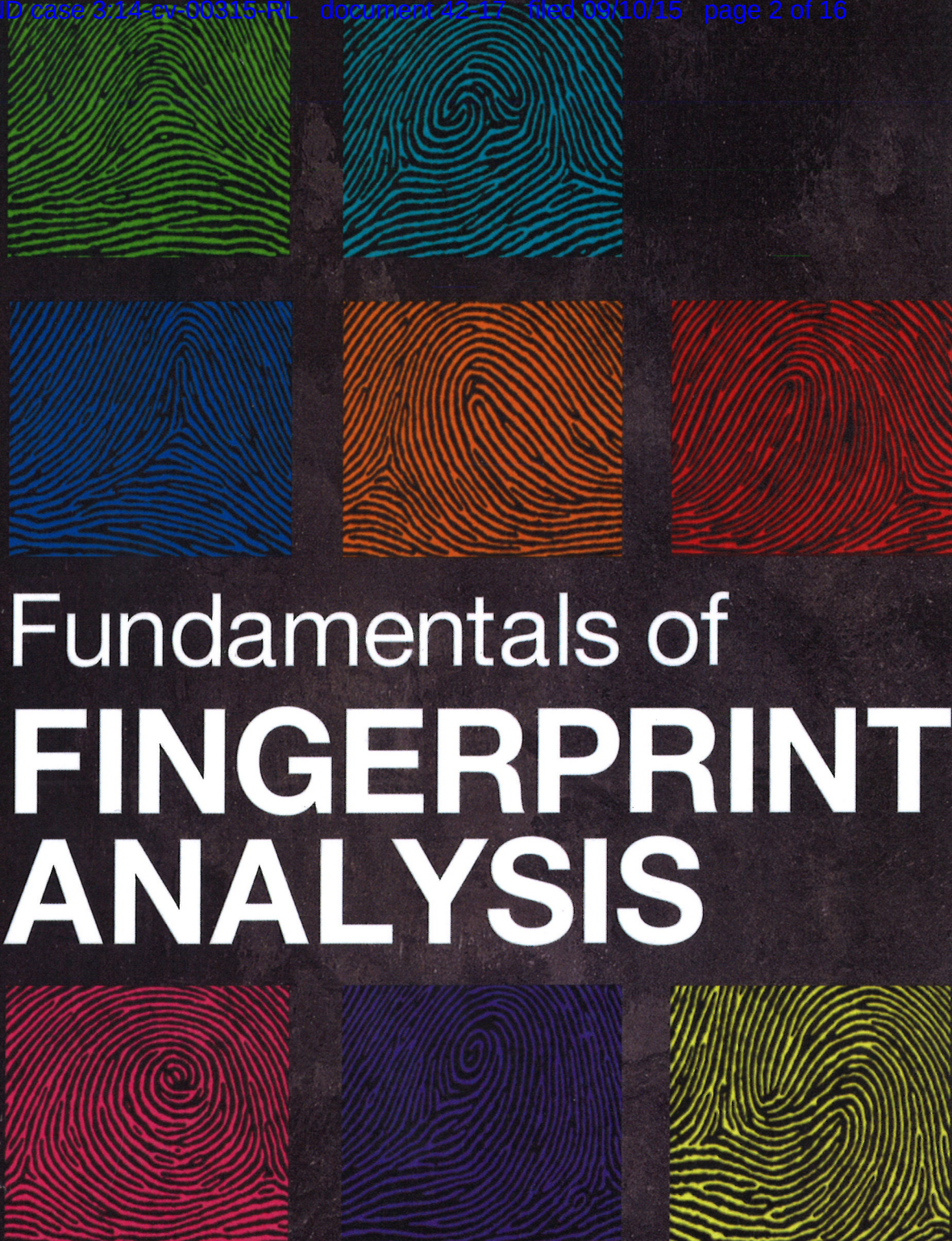


## **EXHIBIT Q**

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Hillary Moses Daluz  
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# Fundamentals of **FINGERPRINT ANALYSIS**

Hillary Moses Daluz



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Hillary Moses Daluz



**CRC Press**

Taylor & Francis Group

Boca Raton London New York

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# Fundamentals of **FINGERPRINT ANALYSIS**

The “CSI effect” has brought an explosion of interest in the forensic sciences, leading to the development of new programs in universities across the world. While dozens of professional texts on the science of fingerprint analysis are available, few are designed specifically for students. An essential learning tool for classes in fingerprinting and impression evidence, *Fundamentals of Fingerprint Analysis* takes students from an understanding of the historical background of fingerprint evidence to seeing how it plays out in a present-day courtroom.

Using a pedagogical format, with each chapter building on the previous one, the book is divided into three sections. The first explains the history and theory of fingerprint analysis, fingerprint patterns and classification, and the concept of biometrics—the practice of using unique biological measurements or features to identify individuals. The second section discusses forensic light sources and physical and chemical processing methods. Section III covers fingerprint analysis with chapters on documentation, crime scene processing, fingerprint and palm print comparisons, and courtroom testimony.

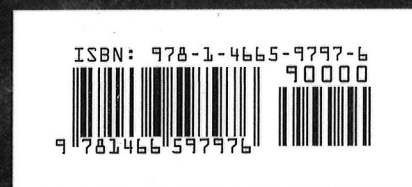
Designed for classroom use, each chapter contains key terms, learning objectives, a chapter summary, and review questions to test students’ assimilation of the material. Ample diagrams, case studies, and photos demonstrate concepts in a way that prepares students for working actual cases.

*Ancillaries including a test bank, figure slides, PowerPoint® lecture slides, and an instructor’s manual are available with qualifying course adoption. A companion workbook, Fingerprint Analysis Laboratory Workbook (ISBN: 978-1-4665-9789-1) is available for purchase for use in courses with a laboratory component.*

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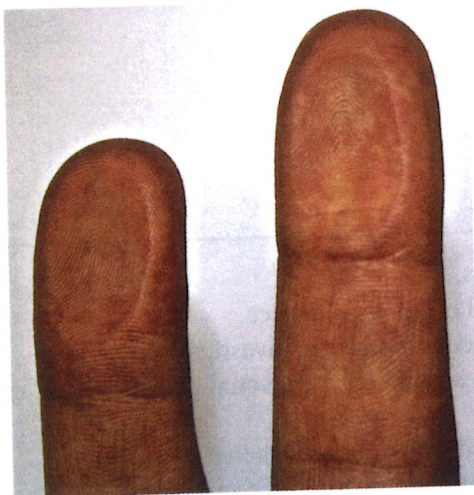
## 1.1 Evolutionary Development of Friction Ridges

Fingerprints, as well as palm prints and footprints, are made up of *friction ridges*. The Scientific Working Group on Friction Ridge Analysis, Study and Technology (SWGFAST) defines a friction ridge as "a raised portion of the epidermis on the palmar or plantar skin, consisting of one or more connected ridge units."<sup>2</sup> The word "palmer" refers to the hand: the palm of the hand, finger joints, and fingertips. The word "plantar" refers to the bottom of the foot and the toes. Friction ridges are minute, raised areas of skin similar in contour to mountain ranges. Just as mountains are pushed up through the earth's crust to the surface, so too are friction ridges pushed up through the layers of the epidermis to the skin's surface. Though friction ridges all appear to be of the same width and height, they are extremely variable. It is not easy to see these variations with the naked eye.

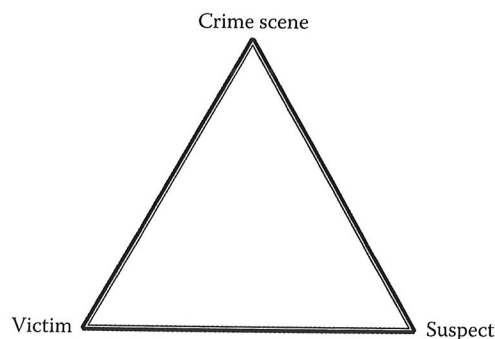
Why do humans and primates have friction ridge skin on hands and feet? The answer is *friction*. Friction is the measure of resistance when the surfaces of two objects are pressed together, or when two objects move against each other. An example is the friction of automobile tires. When the brake is applied with force, the rubber of the tires may leave skid marks on the road. Another example of friction is the action of scraping a wooden surface with sandpaper. The rougher the surface, the more friction is created between two objects.

The friction ridges on the hands come into contact with objects constantly. We use our hands to grip objects throughout our daily lives. We turn doorknobs, drink from glasses, type on keyboards, drive vehicles, and write with pens. Our friction ridges allow us to perform all of these tasks. If we did not have friction ridges on our fingers, we could not easily grip a smooth drinking glass or a cell phone. Friction ridges create a rough, textured surface that provides resistance between our hands and anything we touch (Figure 1.1).

Friction ridges formed over thousands of years of evolutionary development. They are found not only on human hands and feet but also on the hands and feet of other primates (Figure 1.2). They are also found on the prehensile tails of primates (Figure 1.3). This fact was addressed in a thesis written by Johannes Purkinje, a Czech scientist who contributed extensively not only to the science of fingerprint analysis but also to physics and



**Figure 1.1** Friction ridges against a glass surface.



**Figure 1.5** The evidence linkage triangle demonstrates the link between the crime scene, victim, and suspect.

to prove or disprove a fact in contention.”<sup>4</sup> There are two types of evidence: testimonial and physical. *Testimonial evidence* refers to verbal accounts such as eyewitness statements or transcripts of interviews. This type of evidence is subjective, meaning it is subject to either intentional or unintentional biases of the individual. *Physical evidence* includes both physical evidentiary items (weapons, bloody clothing, etc.) and forensic evidence such as fingerprints, trace evidence, and DNA.

A scientist must be unbiased at all times. The key to an impartial forensic examination is *integrity*: recognizing that everyone has inherent biases and consciously pushing those biases aside. Integrity is defined by the *Merriam-Webster* dictionary as “firm adherence to a code of especially moral or artistic values.”<sup>5</sup> It also relates the word integrity to “completeness,” “soundness,” and “incorruptibility.”<sup>5</sup> In the discipline of forensic sciences, your personal and professional integrity must be compatible and irrefutable.

## 1.4 Fingerprint Analysis

Fingerprint evidence is valuable because fingerprints are unique. No two fingerprints are alike. Thus, fingerprint examiners can trace a fingerprint back to its source. Fingerprint comparison is the process of comparing two friction ridge impressions to determine if they came from the same source (i.e., did the same person make both impressions). Fingerprint examiners compare unknown fingerprints from crime scenes or items of evidence to known fingerprints and make a determination as to the source of the prints.

There are two types of structural characteristics of fingerprints that allow fingerprint examiners to compare fingerprints and make identifications: *pattern types* and *minutiae*. Pattern types—arches, loops, and whorls—are not unique to the individual. They are *class characteristics*. Class characteristics are those features that place an individual or object in a group or subcategory. Minutiae (pronounced mi-noo-sha) are *individualizing characteristics*. Individualizing characteristics are those features that are unique to one particular person or thing. Fingerprint examiners analyze both the class characteristics and individualizing characteristics of fingerprints in order to reach a conclusion.

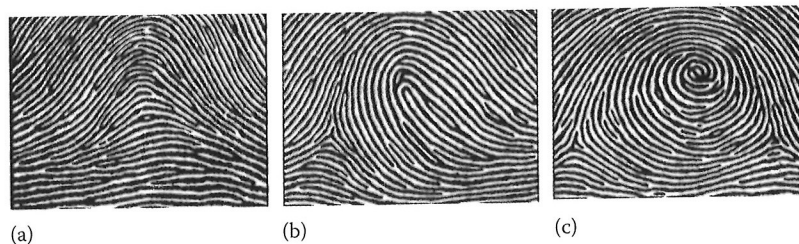
Class and individual characteristics are used to describe many forensic evidentiary items such as shoeprints, tire tracks, biological evidence, and firearms evidence. Examples

of class and individual characteristics are observable everywhere. For example, a suitcase may demonstrate both class and individualizing characteristics. The class characteristics include the following features: size, shape, presence or absence of wheels, color, fabric, number of zippered pockets, and number of zippers. Imagine your suitcase is a red, nylon carry-on suitcase with three zippered pockets and wheels. You check your bag with the airline and expect to identify it when you reach your destination and it is returned to you. If there are 300 suitcases on a revolving luggage carousel, you will look for the class characteristics of your own suitcase to determine which belongs to you. Each class characteristic narrows down the possible suitcases that match yours. Perhaps you will first look for suitcases that are red and then examine the size of each suitcase, then perhaps the presence or absence of wheels.

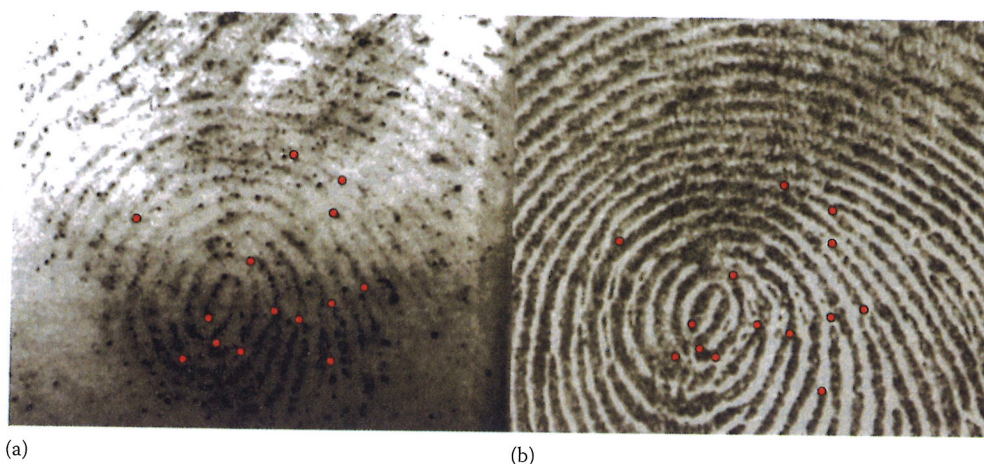
But what if there is another suitcase that looks just like yours? What individualizing characteristics can you use to distinguish your suitcase from its apparent twin? Unique characteristics accumulate on physical items with use. A suitcase might have a tear in the fabric, a dent, a loose wheel, or a missing zipper. Those are individualizing characteristics that may help you identify your suitcase. You may have placed individual characteristics on your bag intentionally by attaching a ribbon to the handle or a luggage tag with your name and contact information. The human brain identifies an object or person in a natural progression from recognizing class characteristics to confirmation by individualizing characteristics. You may not be able to read your luggage tag while your suitcase is coming around the conveyer belt, but you can certainly observe the sizes, colors, and styles of the suitcases as they approach to narrow down the possibilities. When the bag gets close enough for a more rigorous examination of its individualizing characteristics, you can then conclusively determine which bag is yours.

Fingerprint pattern types are class characteristics and are therefore used to narrow down the potential field of candidates who may be the source of the fingerprint in question, just like the color and size of a suitcase narrow down the possibility that suitcase belongs to you. There are three categories of fingerprint patterns: arch, loop, and whorl (Figure 1.6). There are eight subpattern types within those categories: ulnar loop, radial loop, plain whorl, double-loop whorl, central pocket loop whorl, accidental, plain arch, and tented arch (Figure 1.7). Other class characteristics of fingerprints include the presence of creases and scars, the ridge count of a loop, and the whorl tracing of a whorl pattern. These characteristics will be discussed in detail in Chapter 4 of this book.

In order to reach a conclusion, the fingerprint examiner must also analyze the minutiae: the individualizing characteristics in a fingerprint. The word "minutiae" refers to small details. The friction ridges that make up a fingerprint pattern are not continuous,



**Figure 1.6** The three basic fingerprint pattern types: (a) arches, (b) loops, and (c) whorls.



**Figure 1.11** A fingerprint that has been identified to a suspect. (a) a latent fingerprint from a crime scene, (b) the left thumbprint of the suspect.

## 1.5 Uniqueness and Permanence

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Two main premises form the basis for the science of fingerprint identification:

1. Fingerprints are unique.
2. Fingerprints are permanent.

Uniqueness means that there are likely no two people in the world with the same fingerprints. Even identical twins, with identical DNA, have different fingerprints. We know fingerprints are unique because of the inherent randomness of nature. Throughout the history of fingerprint identification, it has been widely accepted that no two people have the exact same fingerprints. Permanence means your fingerprints do not change throughout your lifetime. They form in utero from the deepest layer of the epidermis and do not change as you age.

This text explores the uniqueness and permanence of fingerprints in many contexts. It will first address the background, theory, and history of the science of fingerprint identification; followed by a discussion of the development, visualization, and documentation of latent fingerprints from evidence and crime scenes; and finally fingerprint comparisons and courtroom testimony.

## 1.6 Chapter Summary

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Fingerprints are patterns made by friction ridges, which are raised portions of the epidermis found on the hands and feet. Friction ridges are the result of evolutionary development. They create a rough surface that allows humans to grip objects. Forensic science refers to any science applied to legal matters. Forensic scientists testify to their conclusions and opinions in a court of law. Fingerprints have been used as forensic evidence for

Fingerprints were historically stored in filing cabinets according to their alphanumeric classification designations. When an individual was arrested and fingerprinted, the fingerprint card was classified and the filing cabinets searched according to that classification label. In some agencies, they are still entered and searched by hand. The advent of the *Automated Fingerprint Identification System (AFIS)*, commonly known as the fingerprint computer, has mostly negated the need for manual classification and filing of hard copies of fingerprint records. Fingerprints are now recorded on a scanner (a "livescan" device) attached to a computer. They are stored digitally, just like digital photographs. However, similar to learning about the history of fingerprints, knowledge of historical classification systems gives us a better understanding of pattern types and the analysis of friction ridge impressions. Many employers, as well as fingerprint certification tests, require a working knowledge of the basic classification schemes addressed in the following.

#### 4.6 Henry Classification

Sir Edward Henry, Azizul Haque, and Chandra Bose developed the *Henry Classification System* in 1897.<sup>6</sup> The Henry system became the most widely used classification system in English-speaking countries. Juan Vucetich also developed a classification system used in Spanish-speaking countries. Prior to the advent of both the Vucetich and Henry systems, Bertillon, Purkinje, Galton, and Faulds also worked on fingerprint classifications systems.<sup>7</sup> Classification systems have been modified and applied in countries such as Hungary, Portugal, Prague, Germany, Japan, Spain, Holland, Italy, Russia, Mexico, Egypt, Norway, Cuba, Chile, and France.<sup>6</sup>

Most of these systems involve analyzing the pattern types of the fingers and assigning alphanumeric designations to each finger. In both the Henry and Vucetich systems, the resulting classification resembles a fraction, with a numerator above a classification line and a denominator below the classification line. There may be several sets of letters (both upper and lower case) and numbers both above and below the classification line.

There are six components, or parts, to the Henry Classification System: the *primary*, *secondary*, *subsecondary*, *major*, *final*, and *key*. This text will focus on examples of primary classification. Primary classification assigns numerical value to only the whorl patterns present in the fingerprint record. It is written as a fraction, but unlike a fraction, it is never reduced. One number will appear in the numerator, and one number will appear in the denominator. The fraction line is known as the classification line.

Each finger is numbered from 1 to 10, starting with the right thumb as finger number one, proceeding through the right index, right middle, right ring, and right little fingers. The left thumb is finger number six, followed by the left index, left middle, left ring, and left little fingers. The fingerprint card, also known as a *tenprint card*, is numbered 1–10 (Figure 4.17). The fingers are each assigned a point value if a whorl is found on that finger. The point values decrease by half as you proceed through the remaining eight fingers (Table 4.1). For example, if there is a whorl located on the number one finger (the right thumb), it is assigned a value of 16. If there is a whorl located on the number eight finger (the left middle finger), it is assigned a value of two.

The numerator is the sum of the point values for the *even* numbered fingers plus one. The denominator is the sum of the point values for the *odd* numbered fingers plus one.

fingerprint pattern type. They are patterns in which the ridges enter on one side of the finger, make a rise or wave in the center, and flow out the other side. There are two types of arches: plain arches and tented arches.

Classification systems categorize fingerprint records according to the pattern types found on the fingers. The Henry classification uses alphanumeric designations for fingerprint pattern types and lists them above and below a classification line. NCIC classification is a system that applies a two-letter code to each fingerprint pattern type.

## Review Questions

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1. List the three basic fingerprint pattern types in order from least common to most common.
2. How many deltas are most often observed in the following pattern types?  
Arch  
Loop  
Whorl
3. What are the three requirements of a loop pattern?
4. What are the four subcategories of whorls?
5. How do you "trace" a whorl, and what are the three possible types of whorl tracings?
6. What makes a tented arch different from a plain arch?
7. What is the primary Henry classification of an individual with whorls on his right and left thumbs and index fingers?
8. What is the primary Henry classification for an individual with the following NCIC classification code:

dM7017AA12

dM7219TT16

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## Known Fingerprints

# 5

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### Key Terms

- Exemplars
- Known prints
- Inked prints
- Record prints
- Standards
- Major case prints
- Tenprint cards
- Flats
- Slaps
- Plain impressions
- Writer's palm
- Hypothenar
- Handiprint System®
- Livescan
- Algorithm
- Rigor mortis
- Putrefaction
- Maceration
- Mummification
- Desiccated

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### Learning Objectives

- Define the key terms.
- Name the three methods of recording friction ridge skin.
- Understand the advantages and disadvantages of each process.
- Describe the various methods for recording known prints from decomposing skin.

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### 5.1 Known Fingerprints

In order to analyze friction ridge skin, one must first record the pattern digitally or with fingerprint ink or powder. The resulting records are known as *exemplars* or *known prints*.

They are also known as *inked prints*, *record prints*, or *standards*.<sup>1</sup> Known fingerprints are recorded for four reasons:

1. To serve as an official record of a person's identity
2. To search for a match to a prior arrest record
3. To compare to unknown, or latent, fingerprints
4. To input into the Automated Fingerprint Identification System (AFIS) for subsequent searches

It is therefore important to take comprehensive records of the friction ridge skin in order to provide the best possible exemplars for identification purposes.

Records of the friction ridge skin on the fingers, finger joints, palms, and even feet and toes may be needed for identification. Records of fingers, palms, the writer's palm (side of the hand), and the joints, tips, and sides of fingers are known as *major case prints*. The three most common methods of recording friction ridges are inked impressions, powdered impressions, and digital scans.

## 5.2 Inked Fingerprint Records

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The most common medium for recording friction ridge skin is ink. Inked fingerprints are recorded on *tenprint cards*. Tenprint cards are 8" x 8" printed white cards formatted to official government specifications. A tenprint card, such as the card pictured in Figure 5.1, contains demographic information along with the fingerprints of each of 10 fingers (Figure 5.1). Each finger is rolled in ink and subsequently rolled into the corresponding box on the tenprint card. The finger is rolled from "nail to nail" to capture the entire friction ridge surface. This means the finger must be rolled from one side of the finger (at the nail) all the way around to the other side of the nail (Figure 5.2). A fingerprint rolled from nail to nail should be roughly rectangular in shape (Figure 5.3).

The fingerprints should be rolled with the individual standing slightly back from the table with the arm bent at an approximate 90° angle. When the thumb is rolled, the subject's hand is rotated toward the body. When the fingers are rolled, the subject's hand is rotated away from the body. This allows the hand to be manipulated from the point of most to least resistance. The individual taking the fingerprints controls the subject's hand to ensure the most comprehensive fingerprint record is taken. If the subject attempts to assist by moving his own fingers, the prints will be smudged or incomplete.

The four fingers of the right hand and left hand are inked and recorded simultaneously at the bottom of the tenprint card along with impressions of the thumb. These impressions are known as the *flats*, *slaps*, or *plain impressions*. The flats of the four fingers together are placed in the section of the tenprint card labeled "four fingers taken simultaneously." The sections for the flats of the thumbs are labeled "R. thumb" and "L. thumb." It is important to record information here that may not be available in the previously mentioned rolled prints, such as the ridge detail in the fingertips. This is accomplished by lifting the thumb and fingers up to the tips when the flats are inked and recorded.

# Nature of Latent Fingerprints

# 6

With dramatic suddenness he struck a match, and by its light exposed a stain of blood upon the whitewashed wall. As he held the match nearer, I saw that it was more than a stain. It was the well-marked print of a thumb.

Sherlock Holmes<sup>1</sup>

## Key Terms

- Ridge flow
- Latent fingerprints
- Patent fingerprints
- Plastic fingerprints
- Matrix
- Substrate
- Latent print examiner (LPE)
- Eccrine gland
- Sebaceous sweat (sebum)
- Touch DNA

## Learning Objectives

- Define the key terms.
- Describe and give an example of latent, patent, and plastic fingerprints.
- Explain the duties of a latent fingerprint examiner.
- List the components of latent fingerprint residue.
- Explain why fingerprints cannot be aged.
- Understand touch DNA and how to avoid contamination during collection.

## 6.1 Latent Fingerprints

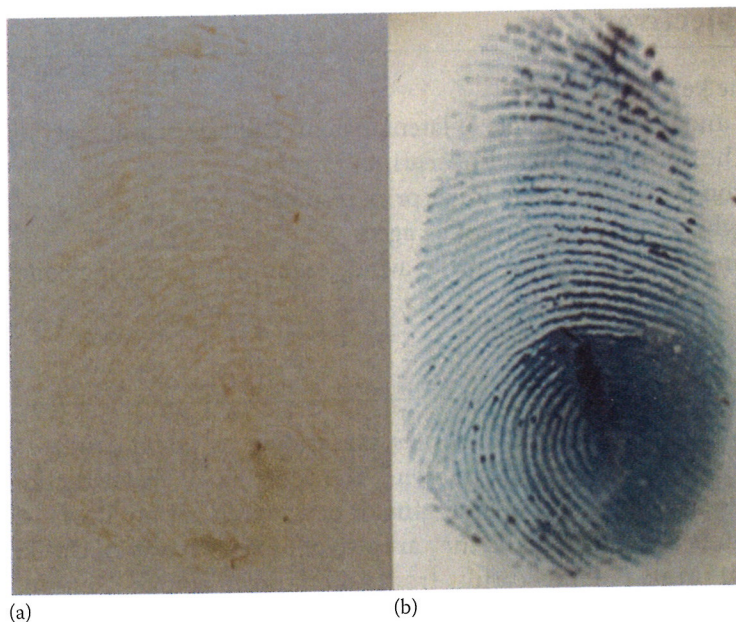
Fingerprints recovered from crime scenes are known as *latent fingerprints*. The word “latent” is a Latin word meaning “hidden.” The Merriam-Webster dictionary defines it as follows: “present and capable of emerging or developing but not now visible, obvious.”<sup>2</sup> Latent fingerprints are invisible, and they are also of unknown origin. Unlike exemplar fingerprints, latent prints are fingerprints from an unknown source. Unknown fingerprints are often referred to simply as *latents*.



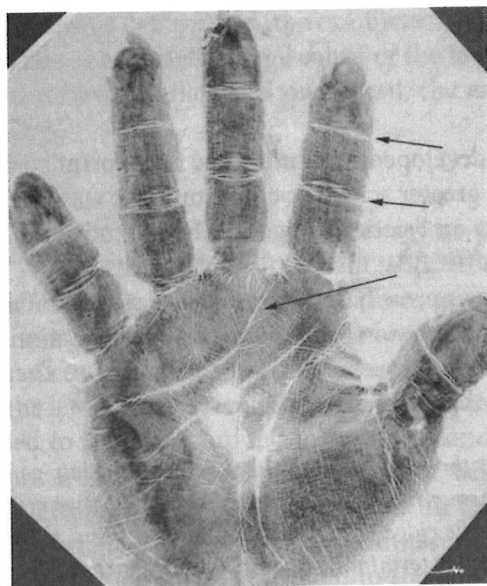
**Figure 6.1** Fingerprints developed from a crime scene with fingerprint powder.

When one imagines fingerprints at crime scenes, what images come to mind? A crime scene investigator diligently twirling a brush coated in black fingerprint powder across a surface, revealing a fingerprint? This image, though accurate, is only one segment of fingerprint analysis. There are many ways to recover invisible fingerprints from items of evidence or from surfaces at a crime scene using both powders and chemical reagents (Figure 6.1).

Not all fingerprints found at crime scenes are invisible, however. *Patent* fingerprints are fingerprints visible to the naked eye. The word “patent” means “readily visible or intelligible: obvious.”<sup>2</sup> Patent prints are visible because they are recorded in a visible medium such as blood, paint, or grease. Though patent prints are visible, they may require chemical processing to improve visibility and contrast. For example, a bloody fingerprint is often processed to improve visibility and contrast. A chemical reagent is applied to turn the light brown fingerprint a blue/black color so it is easier to see and photograph (Figure 6.2). A grease fingerprint may also be enhanced with the use of chemical reagents.



**Figure 6.2** A bloody fingerprint before (a) and after (b) processing with Amido black.



**Figure 16.5** Arrows denote creases of the finger joints and palm.

latent and known prints. However, when they are visible, they are useful for forming a final conclusion. Each level of detail focuses on more and more unique features.

There are other features that augment or lend confidence to a fingerprint conclusion. Scars and creases may appear as straight, curved, or jagged white lines within a print (Figure 16.5). Blisters, cuts, or warts may also be visible in a fingerprint, but these heal and change shape over time. Level one, two, and three details are observed in a particular order based on the methodology fingerprint examiners employ to compare fingerprints. This methodology is commonly referred to as analysis, comparison, evaluation, and verification (*ACE-V*).

### 16.3 ACE-V

*ACE-V* is a scientific methodical evaluation of level one, two, and three detail in context. Regardless of the medium used to record the known fingerprints—ink, powder, or digital—latent print examiners use a process known as *ACE-V* to perform fingerprint comparisons. This methodology *standardizes* the comparison process to ensure that every examiner follows the same steps to identify the source of any latent fingerprint. The *ACE-V* process is not only used to identify the source of a fingerprint but also to exclude an individual as the source of the fingerprint. An *exclusion* conclusion is just as valuable as an *identification* conclusion.

*ACE-V* methodology was developed as an approximation of the scientific method. The components of the scientific method are

- Observation
- Hypothesis
- Experimentation